Synoptic Estimates of Waves and Currents
via Real-Time Assimilation of *In-Situ* Observations

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LONG-TERM GOALS

The long term goal of this effort is to develop a methodology to monitor near-shore waves and currents over large spatial scales using data from in-situ sensors.

OBJECTIVES

The proposed program will develop the capability of monitoring nearshore waves and currents over large scales, and will allow the timely use of information from in-situ sensors. The specific objectives to be addressed are to: 1. Develop a near-real-time capability for assimilating single- or multiple-point in-situ observations into a phase-resolving wave model; 2. Test and validate the methodology against both simulated data and archival field data for both simple and complex beach types; and 3. Conduct a full-scale test of the methodology by applying it in near-real time to a comprehensive field experiment on complex topography.

APPROACH

The procedure being developed makes use of a variational data assimilation capability for the extended-Boussinesq wave model of Wei *et al.* (1996). The approach is to use time-series data from instruments in the interior of a region to estimate the time-dependent boundary conditions for the Boussinesq model at the boundaries of the region. These boundary conditions will yield a Boussinesq-model prediction which matches the data.

WORK COMPLETED

The work completed during the past fiscal year includes development of the mathematical framework for the assimilation procedure, improvements in the numerical implementation of the extended Boussinesq model and its adjoint, and addition of improved wavemaker and run-up models in the parallel Boussinesq code.

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RESULTS

The objective of this program is to develop a methodology to use in-situ, time-series observations from the interior of a near-shore region to determine the time-dependent boundary conditions to be applied to an extended Boussinesq wave model to reproduce the observed wave field.

During the past fiscal year, the first issue addressed was the appropriate approach for specifying the boundary conditions. Two approaches have been examined. The first approach attempts to determine the surface elevation and velocity time histories along the boundaries; this involves using the adjoint velocity and surface-elevation solution to determine the gradient of the error between the predictions and observations with respect to the boundary conditions on velocity and surface elevation. This requires calculation of the gradient from the adjoint solution, as well as storage of the time-history of all three variables on the boundary. A simpler and more efficient approach has also been examined which makes use of impervious boundary conditions, and a 'wavemaker' at the boundaries. The wavemaker is represented by a source term in the continuity equation,localized at the boundaries. The source amplitude is a single variable, and the gradient of the error with respect to the source amplitude is directly proportional to adjoint surface elevation at the boundary, making it simpler to calculate and more efficient to store. This latter, simpler approach is currently being evaluated.

The present assimilation code includes a parallel implementation of the Wei *et al.* (1996) extended Boussinesq model and its adjoint. To apply this code to prediction and assimilation of temporally long data sets, wave breaking and runup of waves on the beach must be accomodated. For this reason, the wave breaking and run-up models of Chen *et al.* (2000) have been implemented in the forward model. In addition, an improved wavemaker capable of generating waves with a prescribed directional spectrum at the deep-water boundary is being implemented. This will allow evaluation of forward model parameterizations of wave breaking by comparing model predictions of spatial and temporal wave breaking patterns with video observations (both SandyDuck data and AROSS data from Duck) in order to identify any improvements in model physics necessary for the success of the assimilation procedure.

IMPACT/APPLICATIONS

The potential applications of the methodology range from determining in a timely manner the conditions on a denied beach, to providing an ongoing, synoptic view of a field experiment in progress, as well as providing a tool for interrogating the near-shore hydrodynamics on beaches with high spatial variability. The results of the proposed program will provide the capability of monitoring near-shore waves and currents over large scales with greater accuracy, and allow the timely use of information from in-situ sensors.

RELATED PROJECTS

This project is part of the ONR Nearshore Canyon Experiment.

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